The study of the unstably-stratified marine atmospheric boundary layer by direct numerical simulation

Oleg A. Druzhinin[1,2], Yuliya I. Troitskaya[1,2] and Sergej S. Zilitinkevich[1,2,,3,4]

[1] Institute of Applied Physics, Russian Acad. Sci., Nizhny Novgorod, Russia
[2] Nizhny Novgorod State University, Nizhny Novgorod, Russia
[3] Finnish Meteorological Institute, P.O. Box 503, 00101 Helsinki, Finland
[4] University of Helsinkini, Helsinki, Finland

Prediction of the properties of the atmospheric flows over sea is important for local and regional weather forecast. This prediction typically relies on the performance of large-scale meteorological models based on bulk formulae for air velocity, temperature and humidity. The bulk formulas relate turbulent fluxes of momentum, heat and vapor to bulk air velocity, humidity and air-sea temperature difference. The most widely used parameterizations used to compute the coefficients of proportionality in the bulk formulae are formulated on the basis of the Monin-Obukhov similarity theory (MOST) for different types of air stratification (stable, neutral and unstable). In our previous studies we showed that MOST quite accurately predicts the properties of the air-flow over waved water surface under neutral and stable stratification conditions provided that stratification effects are relatively weak and flow is in a statistically stationary state. In the present work, we perform direct numerical simulation and study the air flow over a waved water surface under unstable stratification conditions where the sea surface temperature is larger than the bulk air temperature. Such situation occurs in the tropical cyclone conditions as well as in polar lows at high latitudes. Our results show that in this case, the air flow dynamics is dominated by the development of large-scale cylindrical coherent vortex structures elongated in the direction of the mean wind. These structures cause a notable deviations from the MOST predictions for the air velocity and temperature profiles.

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